CDR pathway	Scale potential - low (tCO2/y)	Scale potential - high (tCO2/y)	Job creation rate - low (jobs/Mtpa)	Job creation rate - high (jobs/Mtpa)	Total jobs - low (jobs)	Total jobs - high (jobs)
Forests	5,000,000	6,000,000	27	3,573	135	21,437
Agricultural soils	11,380	379,685	578	1,033	7	392
Salt Marshes	37,600	117,500	341	1,890	13	222
Biomass Direct Storage	805,273	1,171,219	1,260	2,100	1,015	2,460
Timber Building Products	N/A	4,599,529	4,050	19,620	N/A	90,243
Other Biomass Building Products	113,791	124,588	1,646	2,785	187	347
Pyrolysis (biochar) and storage	398,096	1,100,630	1,365	2,520	543	2,774
Pyrolysis (bioliquid) and storage	426,386	526,713	1,365	2,520	582	1,327
Microalgae in Ponds	1,841,535	7,762,541	347	1,948	638	15,122
Microalgae in Open Water	N/A	N/A	N/A	N/A	N/A	N/A
Macroalgae in Open Water	N/A	N/A	525	980	N/A	N/A
BECCS to Electricity	563,691	1,007,248	1,365	2,520	769	2,538
BECCS to Fuels	112,738	1,007,248	1,365	2,520	154	2,538
Surficial Mineralization	653,696	1,257,108	1,286	2,275	841	2,860
Terrestrial Enhanced Weathering	3,115,719	11,683,946	1,286	2,275	4,008	26,581
Coastal Enhanced Weathering	42,176	100,078	1,286	2,275	54	228
Mineral Alkalinity Enhancement	1,551,797	2,069,063	919	1,645	1,426	3,404
CO2 Stripping	1,551,797	2,069,063	604	1,155	937	2,390
Electrochemical Alkalinity Production	1,551,797	2,069,063	919	1,645	1,426	3,404
Direct Air Capture	6,784,364	14,925,600	840	1,540	5,699	22,985
Conventional Storage	0	0	1,851	3,612	0	0
In-situ Mineralization	0	0	1,851	3,612	0	0
Ex-situ Mineralization	N/A	19,527,200	840	1,540	N/A	30,072

Note: *Scale estimates represent the potential deployment scale if all of one of the State's resources (e.g., biomass, coastal area) were devoted to a CDR pathway. These values are not an estimate of the likely deployment scale in MA. They are a large overestimate, due to the feasibility limits and advisability issues discussed in the report.*

Forests

Scale potential (tCO2e/y)	
Low	5,000,000
High	6,000,000

Data				
Parameter	Value	Unit	Notes	Source
Lower bound removal estimate - total	5,000,000	tCO2e/y	Assumes minimal natural disturbances and includes passive removals	MA Forest Carbon Study
Upper bound removal estimate - total	6,000,000	tCO2e/y	Assumes minimal natural disturbances and includes passive removals	MA Forest Carbon Study
Lower bound removal estimate - active removals only	100,000	tCO2e/y	Reforestation and tree planting (active removal) capacity, low end of range	MA Forest Carbon Study
Upper bound removal estimate - active removals only	600,000	tCO2e/y	Reforestation and tree planting (active removal) capacity, high end of range	MA Forest Carbon Study

Explanation and assumptions:
Forestry removal potential was sourced from the Massachusetts EEA Forest Carbon Study, which analyzes the impact of alternative land-use scenarios on terrestrial carbon storage and sequestration in Massachusetts. This study was published in 2025, and was a joint effort between the Harvard Forest project and the University of Massachusetts, and quantified the total amount of removal potential (5-6 MtCO2e / year) from forests.

The Forest Carbon Study also estimates the additional removal capacity that could come from active land management through reforestation and tree planting (0.1 to 0.6 MtCO2e / year).

Please see the Forest Carbon Study's executive summary (Pages 6-7 in the report) for more information.

Agricultural soils

Scale potential (tCO2e/y)	
Low	11,380
High	379,685

Data				
Parameter	Value	Unit	Notes	Source
Amount of farmland in MA	464451	acres	Amount of farmland is based on the USDA 2022 Census of Agriculture	Agricultural Resources Facts and Statistics | Mass.gov
Carbon storage rate - low	0.11	tCO2e/ha/yr	Assumes low sequestration rate for soil approaches in the UK	https://pubs.rsc.org/en/content/articlepdf/2016/em/c6em00386a
Carbon storage rate - high	3.67	tCO2e/ha/yr	Assumes high sequestration rate for soil approaches in the UK	https://pubs.rsc.org/en/content/articlepdf/2016/em/c6em00386a
US average percentage of farmers cover cropping in 2023	45	%	Assumes this percentage holds yearly and applies to MA	https://ag.purdue.edu/commercialag/ageconomybarometer/farmers-remain-cautiously-optimistic-about-agricultural-economy/
Acre to ha conversion	0.41			Conversion factor
Amount of farmland in MA available for cover cropping	103456	ha		Calculated
Lower bound removal estimate	11380	tCO2e/y	Assumes low soil carbon sequestration rate	Calculated
Upper bound removal estimate	379685	tCO2e/y	Assumes high soil carbon sequestration rate	Calculated

Explanation and assumptions:
Agricultural soils annual CDR potential was calculated by using the carbon storage potential rate for a range of agricultural soil approaches and the amount of farmland available for agricultural soil CDR.

The amount of farmland available was calculated by estimating the farmland that could be changed to cover cropping, which was then used as a proxy for all agricultural soil methods. The land available for cover cropping was calculated using the total amount of farmland in MA and the average US percentage of farmers that are currently cover cropping.

Data:
- the amount of farmland in MA
- the carbon storage rate of agricultural soil methods
- the US average percentage of farmers that cover crop in 2023

Assumptions:
- the US average percentage of farmers that cover crop in 2023 holds yearly and applies to MA
- all farmland available for cover cropping is used for agricultural soils CDR

Salt marshes

Scale potential (tCO2e/y)	
Low	37,600
High	117,500

Data				
Parameter	Value	Unit	Notes	Source
Total salt marsh acreage in MA	47,000	acres	Assumes that all 47000 acres have experienced equal and significant enough degradation to warrant restoration and are not currently delivering any removals	Massachusetts Blue Carbon Financial Incentive Program Feasibility Study
Removal capacity for salt marsh - low	0.80	tCO2/acre/y	Lower removal range for intact salt marshes	Massachusetts Blue Carbon Financial Incentive Program Feasibility Study
Removal capacity for salt marsh - high	2.50	tCO2/acre/y	Upper removal range for intact salt marshes	Massachusetts Blue Carbon Financial Incentive Program Feasibility Study
Lower bound removal estimate	37,600	tCO2e/y	Assumes low salt marsh removal capacity	Calculated
Upper bound removal estimate	117,500	tCO2e/y	Assumes high salt marsh removal capacity	Calculated

Explanation and assumptions:
Salt marsh annual CDR potential was calculated utilizing the recently completed Massachusetts Blue Carbon Study, which was prepared for the Massachusetts Department of Fish and Game by Ridley & Associates, Inc. and Silvestrum Climate Associates. Using the available salt marsh area in MA and the range of salt marsh carbon removal rates provided in the report, the scale was calculated

Data:
- the amount of salt marsh area in MA
- the carbon storage rate of salt marshes

Assumptions:
- all salt marsh area in MA is eligible to be restored

Biomass direct storage

Scale potential (tCO2e/y)	
Low	805,273
High	1,171,219

Data				
Parameter	Value	Unit	Notes	Source
Forestry wastes produced in MA	47234	dry tons/y	Assumes forestry wastes (all included in the report except for small diameter trees) can be used in BDS	https://bioenergykdf.ornl.gov/bt23-forestry-download?f%5B0%5D=bt23_forestry_scenario_name%3Anear-term
Agricultural waste production	21594	dry tons/y	Assumes forestry wastes (all included in the report except for small diameter trees) can be used in BDS	https://bioenergykdf.ornl.gov/bt23-forestry-download?f%5B0%5D=bt23_forestry_scenario_name%3Anear-term
Other wet wastes	641449	dry tons/y	Assumes other wet waste (sludge, manure, and food waste) can be used in BDS	https://bioenergykdf.ornl.gov/bt23-wastes-download?f%5B0%5D=bt23_subclass_facet%3AOther%20wet%20waste
Agricultural biomass conversion upper	2	tCO2e/ton		https://www.pnas.org/doi/10.1073/pnas.2217695120#:~:text=The%20weight%20fraction%20of%20carbon,deemed%20to%20be%20less%20controversial.
Agricultural biomass conversion lower	1.5	tCO2e/ton		https://www.pnas.org/doi/10.1073/pnas.2217695120#:~:text=The%20weight%20fraction%20of%20carbon,deemed%20to%20be%20less%20controversial.
Forestry waste conversion efficiency	1.72	tCO2e/ton	Uses the carbon fraction of forest biomass in the linked source and converts to CO2	Proposal to integrate AFOLU

Explanation and assumptions:
Biomass direct storage annual CDR potential was calculated by assuming all biomass waste in MA across the forestry, agricultural, and wastewater industries are used. No purpose grown crops are included in the scale estimate.

Data:
- the amount of forestry waste, agricultural waste, and other wet wastes in MA . Wet waste is given in dry tons.
- the carbon storage rate of biomass

Assumptions:
- all forestry waste, agricultural waste, and other wet wastes in MA are used in biomass direct storage
- MA does not use purpose-grown crops in biomass direct storage

Sludge conversion efficiency upper	1.63	tCO2e/ton	Assumes the high carbon content of sludge measured in the linked source and converts to CO2	Slow-pyrolysis of municipal sewage sludge: biochar characteristics and advanced thermodynamics
Sludge conversion efficiency lower	1.08	tCO2e/ton	Assumes the low carbon content of sludge measured in the linked source and converts to CO2	Slow-pyrolysis of municipal sewage sludge: biochar characteristics and advanced thermodynamics
Ag tons removed upper	43188	tCO2e/y		Calculated
Ag tons removed lower	32391	tCO2e/y		Calculated
Forest waste tons removed	81400	tCO2e/y		Calculated
Sludge tons removed higher	1046631	tCO2e/y		Calculated
Sludge tons removed lower	691482	tCO2e/y		Calculated
Upper bound removal estimate	1171219	tCO2e/y		Calculated
Lower bound removal estimate	805273	tCO2e/y		Calculated

Timber building products

Scale potential (tCO2e/y)	
Low	N/A
High	4,599,529

Data				
Parameter	**Value**	**Unit**	**Notes**	**Source**
Timber removal potential	4	tCO2e/hectare/y	Assumes that harvesting timber for building products operates at a sustainable "medium" rate of harvesting	Wood Vault: remove atmospheric CO2 with trees, store wood for carbon sequestration for now and as biomass, bioenergy and carbon reserve for the future | Carbon Balance and Management | Full Text
Total timberland in MA	2841421	acres	Assumes that no meaningful changes have occurred to the amount of MA timberland since 2021, though report was produced in 2025	Forests of Massachusetts, 2021: FIA annual snapshot.
Hectare Conversion Factor	2.47	acres/hectare	Unit conversion	Conversion
Total MA Hectares of Timberland	1149882	hectares	Unit conversion	Calculated
Total tCO2 potential from MA timberland	4599529	tCO2e/y	Assumes that all hectares of MA timberland are utilized to produce mass timber building products, as well as that the timber is harvested under a "medium" sustainability rate.	Calculated

Explanation and assumptions:
Timber building prodcuts annual CDR potential was calculated by assuming all timber production in MA is used in building products. This calculation is based on the amount of timberland in MA and the carbon removal potential of timber.

Data:
- the amount of timberland in MA
- the carbon removal potential of timber

Assumptions:
- harvesting timber for building products operates at a sustainable "medium" rate of harvesting
- no meaningful changes to the amount of MA timberland since 2021
- all timber produced in MA is used in timber building products

Other biomass building products

Scale potential (tCO2e/y)	
Low	113,791
High	124,588

Data				
Parameter	**Value**	**Unit**	**Notes**	**Source**
Agricultural wastes	21594	dry tons/y	Assumes agricultural waste (ag processing waste and ag residues) can be used in biomass building products	https://bioenergykdf.ornl.gov/bt23-agricultural-download?f%5B0%5D=bt23_agricultural_scenario_facet%3Anear-term
Forestry wastes	47234	dry tons/y	Assumes forestry wastes (all included in the report except for small diameter trees) can be used in biomass building products	https://bioenergykdf.ornl.gov/bt23-forestry-download?f%5B0%5D=bt23_forestry_scenario_name%3Anear-term
Agricultural biomass conversion upper	2	tCO2e/ton		https://www.pnas.org/doi/10.1073/pnas.2217695120#:~:text=The%20weight%20fraction%20of%20carbon,deemed%20to%20be%20less%20controversial.
Agricultural biomass conversion lower	1.5	tCO2e/ton		https://www.pnas.org/doi/10.1073/pnas.2217695120#:~:text=The%20weight%20fraction%20of%20carbon,deemed%20to%20be%20less%20controversial.
Forestry waste conversion efficiency	1.72	tCO2e/ton	Uses the carbon fraction of forest biomass in the linked source and converts to CO2	Proposal to integrate AFOLU
Ag tons removed lower bounds	32391	tCO2e/y		Calculated
Ag tons removed upper bounds	43188	tCO2e/y		Calculated
Forest waste tons removed	81400	tCO2e/y		Calculated
Upper bound removal estimate	124588	tCO2e/y		Calculated
Lower bound removal estimate	113791	tCO2e/y		Calculated

Explanation and assumptions:
Other biomass building products annual CDR potential was calculated by assuming all biomass waste in MA across the forestry and agricultural industries are used. No purpose grown crops are included in the scale estimate, though certain crops like hemp could be grown specifically for other biomass building products.

Data:
- the amount of forestry waste and agricultural waste in MA
- the carbon storage rate of biomass

Assumptions:
- all forestry waste and agricultural waste in MA are used in biomass direct storage
- MA does not use purpose-grown crops in biomass building products

Pyrolysis (biochar) and storage

Scale potential (tCO2e/y)	
Low	398,096
High	1,100,630

Data				
Parameter	**Value**	**Unit**	**Notes**	**Source**
Woody biomass (forest waste) production	47234	dry tons/y	Assumes forestry wastes (all included in the report except for small diameter trees) can be used for biochar	https://bioenergykdf.ornl.gov/bt23-forestry-download?f%5B0%5D=bt23_forestry_scenario_name%3Anear-term
Herbaceous biomass (agricultural waste) production	21594	dry tons/y	Assumes agricultural waste (ag processing waste and ag residues) can be used for biochar	https://bioenergykdf.ornl.gov/bt23-agricultural-download?f%5B0%5D=bt23_agricultural_scenario_facet%3Anear-term

Explanation and assumptions:
Pyrolysis (biochar) and storage annual CDR potential was calculated by assuming all biomass waste in MA across the forestry, agricultural, and wastewater industries are used to create biochar. No purpose grown crops are included in the scale estimate.

Data:
- the amount of forestry waste, agricultural, and other wet waste in MA. Wet waste is given in dry tons.
- the conversion rate of biomass to biochar
- the carbon storage rate of biochar

Wastewater sludge production	641449	dry tons/y	Assumes other wet waste (sludge, manure, and food waste) can be used for biochar. This is an overestimate because not all waste, especially food waste, will be able to be carbonized.	https://bioenergykdf.ornl.gov/bt23-wastes-download?f%5B0%5D=bt23_subclass_facet%3AOther%20wet%20waste
Woody biomass to biochar conversion efficiency upper bound	0.2	ton biochar / ton woody biomass	Assumes high end of conversion efficiency range	Life-cycle assessment and techno-economic analysis of biochar produced from forest residues using portable systems
Woody biomass to biochar conversion efficiency lower bound	0.13	ton biochar / ton woody biomass	Assumes low end of conversion efficiency range	Life-cycle assessment and techno-economic analysis of biochar produced from forest residues using portable systems
Wastewater sludge biomass to biochar conversion efficiency upper bound	0.61	ton biochar / ton wastewater sludge biomass	Assumes high end of conversion efficiency range	Slow-pyrolysis of municipal sewage sludge: biochar characteristics and advanced thermodynamics
Wastewater sludge biomass to biochar conversion efficiency lower bound	0.31	ton biochar / ton wastewater sludge biomass	Assumes low end of conversion efficiency range	Slow-pyrolysis of municipal sewage sludge: biochar characteristics and advanced thermodynamics
Herbaceous biomass to biochar conversion efficiency upper bound	0.32	wt%	Assumes high end of conversion efficiency range	https://www.sciencedirect.com/science/article/pii/S0165237025000579
Herbaceous biomass to biochar conversion efficiency lower bound	0.21	wt%	Assumes low end of conversion efficiency range	https://www.sciencedirect.com/science/article/pii/S0165237025000579
tCO2e per ton biochar removal equivalence upper bounds	2.7	tCO2e/ton biochar	Assumes most efficient sequestration	Biochar Carbon Credit Analysis - BF Reports 2022
tCO2e per ton biochar removal equivalence lower bounds	1.9	tCO2e / ton biochar	Assumes least efficient sequestration	Biochar Carbon Credit Analysis - BF Reports 2022
Upper Range of dry forest-residue biomass biochar production	9447	ton/y	N/A	Calculated
Lower Range of dry forest-residue biomass biochar production	6140	ton/y	N/A	Calculated
Wastewater upper range biochar production	391284	ton/y	N/A	Calculated
Wastewater lower range biochar production	198849	ton/y	N/A	Calculated
Herbaceous biomass upper range biochar production	6910	ton/y	N/A	Calculated
Herbaceous biomass lower range biochar production	4535	ton/y	N/A	Calculated
Upper range total biochar production	407641	ton/y	Assumes maximum harvesting of woody biomass, that all wastewater sludge can be used, and highest conversion efficiency for all feedstocks	Calculated
Lower range total biochar production	209524	ton/y	Assumes minimum harvesting of woody biomass, that all wastewater sludge can be used, and lowest conversion efficiency for all feedstocks	Calculated
Upper bound removal estimate	1100630	tCO2e/y	Assumes max biochar production and max sequestration potential	Calculated
Lower bound removal estimate	398096	tCO2e/y	Assumes minimum biochar production and minimum sequestration potential	Calculated

Assumptions:
- all forestry waste, agricultural waste, and other wet waste in MA are used to create biochar
- MA does not use purpose-grown crops to create biochar
- lab scale conversion efficiencies apply at scale

Pyrolysis (bioliquid) and storage

Scale potential (tCO2e/y)	
Low	426,386
High	526,713

Data				
Parameter	**Value**	**Unit**	**Notes**	**Source**
Agricultural wastes	21594	dry tons/y	Assumes agricultural waste (ag processing waste and ag residues) can be used for biolliquid	https://bioenergykdf.ornl.gov/bt23-agricultural-download?f%5B0%5D=bt23_agricultural_scenario_facet%3Anear-term
Forestry wastes	47234	dry tons/y	Assumes forestry wastes (all included in the report except for small diameter trees) can be used ifor bioliquid	https://bioenergykdf.ornl.gov/bt23-forestry-download?f%5B0%5D=bt23_forestry_scenario_name%3Anear-term

Explanation and assumptions:
Pyrolysis (bioliquid) and storage annual CDR potential was calculated by assuming all biomass waste in MA across the forestry, agricultural, and wastewater industries are used to create bioliquid. No purpose grown crops are included in the scale estimate.

Data:
- the amount of forestry waste, agricultural, and other wet waste in MA . Wet waste is given in dry tons.
- the conversion rate of biomass to bioliquid
- the carbon storage rate of bioliquid

Other wet wastes	641449	dry tons/y	Assumes other wet waste (sludge, manure, and food waste) can be used for bioliquid. This is an overestimate because not all waste, especially food waste, will be able to be carbonized.	https://bioenergykdf.ornl.gov/bt23-wastes-download?f%5B0%5D=bt23_subclass_facet%3AOther%20wet%20waste
Woody biomass to bio-oil conversion efficieny	0.6	wt%	Assumes high range of woody biomass (beech and poplar)	https://www.sciencedirect.com/science/article/abs/pii/S0165237020302023
Herbaceous biomass to bio-oil conversion efficiency	0.5	wt%	Assumes low range of herbaceous biomass (straw and miscanthus)	https://www.sciencedirect.com/science/article/abs/pii/S0165237020302023
Wastewater sludge biomass to bio-oil conversion efficiency	0.33	wt%	Assumes exact conversion efficiency of one study utilizing sludge with sawdust mixed in	https://www.sciencedirect.com/science/article/abs/pii/S0306261917307596#:~:text=The%20purpose%20of%20using%20the,COD%20of%20this%20waste%20stream.
tCO2e per ton bio-oil removal upper bound	2.1	tCO2/ton bio-oil		https://charmindustrial.com/blog/modular-pyrolysis-massive-impact
tCO2e per ton bio-oil removal lower bound	1.7	tCO2/ton bio-oil		https://charmindustrial.com/blog/modular-pyrolysis-massive-impact
Agricultural waste bio-liquid production	10797	tons		Calculated
Forest waste bio-oil production	28340	tons		Calculated
Wastewater biomass to bio-oil production	211678	tons		Calculated
Total bio-oil production	250815	tons		Calculated
Upper bound removal estimate	526713	tCO2e/y	Assumes max sequestration potential	Calculated
Lower bound removal estimate	426386	tCO2e/y	Assumes minimum sequestration potential	Calculated

Assumptions:
- all forestry waste, agricultural waste, and other wet waste in MA are used to create bioliquid
- MA does not use purpose-grown crops to create bioliquid
- lab scale conversion efficiencies apply at scale

Microalgae in ponds

Scale potential (tCO2e/y)	
Low	1,841,535
High	7,762,541

Data				
Parameter	Value	Unit	Notes	Source
Available land in MA to convert to microalgae in ponds	79000	ha	Uses the MA Forest Study's Table 10 of the amount of land in MA that is available to be converted to forest (i.e., for reforestation). Assumes that this land can be similarly converted to microalgae in pond cultivation.	download
Ratio of land for ponds to total facility size	0.7		Assumes a facility in MA would have the same ratio as the modeled facility in an NREL study	Algal Biomass Production via Open Pond Algae Farm Cultivation: 2020 State of Technology and Future Research
Average annual microalgae production of ponds - low (open ponds)	9.7	g/m2/day	Assumes a open pond (raceway pond) set up and based on an NREL literature review	Techno-Economic Analysis for the Production of Algal Biomass via Closed Photobioreactors: Future Cost Potential Evaluated Across a Range of Cultivation System Designs
Average annual microalgae production of ponds - high (flat panel PBR)	20.5	g/m2/day	Assumes a flat panel photobioreactor set-up and based on an NREL literature review	Techno-Economic Analysis for the Production of Algal Biomass via Closed Photobioreactors: Future Cost Potential Evaluated Across a Range of Cultivation System Designs
Grams to tons conversion	1000000	g/t	1,000,000 grams are in 1 ton	Conversion
m2 to ha conversion	10000	m2/ha	10,000 m2 are in 1 ha	Conversion
Days operational in MA (open ponds)	244	days/y	Operational days of microalgae ponds based on the climate of MA. Four months (Dec, Jan, Feb, and Mar,) have average monthly low temperatures below freezing and so are assumed inoperable for microalgae in ponds.	Climate
Days operational in MA (flat panel PBR)	365	days/y	Assumes photobioreactors can operate year-round, since they are operated within a greenhouse	
Average annual microalgae production of ponds - low (open ponds)	23.7	t algae per ha per year		Calculated
Average annual microalgae production of ponds - high (flat panel PBR)	74.8	t algae per ha per year		Calculated
Biomass conversion upper	2	tCO2e/ton algae		https://www.pnas.org/doi/10.1073/pnas.2217695120#:~:text=The%20weight%20fraction%20of%20carbon,deemed%20to%20be%20less%20controversial.
Biomass conversion lower	1.5	tCO2e/ton algae		https://www.pnas.org/doi/10.1073/pnas.2217695120#:~:text=The%20weight%20fraction%20of%20carbon,deemed%20to%20be%20less%20controversial.
Upper bound removal estimate	7762541	tCO2e/y		Calculated
Lower bound removal estimate	1841535	tCO2e/y		Calculated

Explanation and assumptions:
Microalgae in ponds annual CDR potential was constrained by the amount of available land in MA that could be converted into microalgae ponds. The amount of available land was taken from the MA Forest Carbon Study's estimate of the available rural land in the state that could be converted to forests (Table 10), which is additional land in the state that does not include land that is suitable for agricultural use or is developed. It is assumed that this land could be converted into microalgae ponds instead of forests, since it is land identified by the state that could be converted for CDR purposes.

Two methods of microalgae in pond cultivation were considered: microalgae cultivated in open (raceway) ponds and microalgae cultivated in photobioreactors, which can be oriented vertically or horizontally. Each of these set-ups have different implications for the algal production per ha of area.

Data:
- the amount of the available rural land in MA that could be converted to forests
- the algal production rate of microalgae in open ponds
- the algal production rate of microalgae in flat-panel photobioreactors
- the carbon storage rate of biomass

Assumptions:
- all land that could be converted to forests could instead be converted to microalgae ponds
- microaglae in open ponds can only be cultivated 8 months out of the year, when MA temperatures would not cause the ponds to freeze
- microalgae in flat-panel photobioreactors can be operated year-round

Microalgae in open water

Scale potential (tCO2e/y)	
Low	N/A
High	N/A

Data				
Parameter	Value	Unit	Notes	Source
N/A	N/A	N/A	N/A	N/A

Explanation and assumptions:
Microalgae cultivation in open water is too early-stage and has too many uncertainties to estimate the maximum potential deployment in Massachusetts.

Macroalgae in open water

Scale potential (tCO2e/y)	
Low	N/A
High	N/A

Data				
Parameter	Value	Unit	Notes	Source
Territorial Sea + Coastal Water Zone Area	2269	sq miles	Assumes all territorial sea and coastal water can be utilized and is fit for deployment	State Area Measurements and Internal Point Coordinates https://www2.census.gov/geo/pdfs/reference/GARM/Ch15GARM.pdf
			Outlines Territorial Sea and Coastal Water definitions, shows why both can be used for macroalgae	Ch15GARM.pdf
Conversion sq mi to sq km	2.59	sq km / sq mi	N/A	Conversion
Sequestration factor	0.0007	sq km / ton C	Assumes scaling down from 73k sq km per 100Mt is accurate; this taken from pg 133 of the linked source	A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration | The National Academies Press
Total eligible area for TSCW zone approach	5877	sq km		Calculated
Upper bound removal estimate	8395261	tCO2e/y		Calculated

Note: This calculation is a estimate of the maximum potential of macroalgae in open water that MA could deploy given available ocean area. This scale of deployment is highly unlikely due to the uncertainty in the efficacy of the approach in MA waters (i.e., MA coastal waters are too shallow for secure storage) as well as the need for multiple permitting, legal, and governance issues to align (i.e., MA is allowed to transport algae out to the deep ocean and MA is allowed to sink all the algae in the ocean). Because of these uncertainties, the scale is evaluated as unknown.

Explanation and assumptions:
Macroalgae in open water annual CDR potential was constrained by the amount of available surface ocean area that MA has jurisdiction over, which is the state's territorial sea and coastal waters.

Data:
- the ocean area in MA's territorial sea and coastal waters
- the area needed for macroalgae per ton of CO2 removal

Assumptions:
- all of the ocean area that MA has jurisdiction over is converted to macroalgae in open water operations

BECCS to electricity

Scale potential (tCO2e/y)	
Low	563,691
High	1,007,248

Data				
Parameter	Value	Unit	Notes	Source
Agricultural wastes	21594	dry tons/y	Assumes agricultural waste (ag processing waste and ag residues) can be used for BECCS	https://bioenergykdf.ornl.gov/bt23-agricultural-download?f%5B0%5D=bt23_agricultural_scenario_facet%3Anear-term
Forestry wastes	47234	dry tons/y	Assumes forestry wastes (all included in the report except for small diameter trees) can be used for BECCS	https://bioenergykdf.ornl.gov/bt23-forestry-download?f%5B0%5D=bt23_forestry_scenario_name%3Anear-term
Other wet wastes	641449	dry tons/y	Assumes other wet waste (sludge, manure, and food waste) can be used for BECCS	https://bioenergykdf.ornl.gov/bt23-wastes-download?f%5B0%5D=bt23_subclass_facet%3AOther%20wet%20waste
Agricultural biomass conversion upper	2	tCO2e/ton		https://www.pnas.org/doi/10.1073/pnas.2217695120#:~:text=The%20weight%20fraction%20of%20carbon,deemed%20to%20be%20less%20controversial.
Agricultural biomass conversion lower	1.5	tCO2e/ton		https://www.pnas.org/doi/10.1073/pnas.2217695120#:~:text=The%20weight%20fraction%20of%20carbon,deemed%20to%20be%20less%20controversial.
Forestry waste conversion efficiency	1.72	tCO2e/ton	Uses the carbon fraction of forest biomass in the linked source and converts to CO2	Proposal to integrate AFOLU
Sludge conversion efficiency upper	1.63	tCO2e/ton	Assumes the high carbon content of sludge measured in the linked source and converts to CO2	Slow-pyrolysis of municipal sewage sludge: biochar characteristics and advanced thermodynamics
Sludge conversion efficiency lower	1.08	tCO2e/ton	Assumes the low carbon content of sludge measured in the linked source and converts to CO2	Slow-pyrolysis of municipal sewage sludge: biochar characteristics and advanced thermodynamics
BECCS conversion upper	0.9		Assumes high end of biomass conversion efficiency for the range of BECCS to electricity scenarios using agricultural and forestry wastes in the linked source	A comparative analysis of the efficiency, timing, and permanence of CO2 removal pathways - Energy & Environmental Science (RSC Publishing)
BECCS conversion lower	0.7		Assumes low end of biomass conversion efficiency for the range of BECCS to electricity scenarios using agricultural and forestry wastes in the linked source	A comparative analysis of the efficiency, timing, and permanence of CO2 removal pathways - Energy & Environmental Science (RSC Publishing)
Upper bound removal estimate	1007248	tCO2/y	Assumes high conversion efficiency and that all biomass waste is used for BECCS	Calculated
Lower bound removal estimate	563691	tCO2/y	Assumes low conversion efficieny and that all biomass waste is used for BECCS	Calculated

Explanation and assumptions:
BECCS to electricity annual CDR potential was calculated by assuming all biomass waste in MA across the forestry, agricultural, and wastewater industries are used to in the BECCS to electricity process. No purpose grown crops are included in the scale estimate. The estimate of available waste biomass generated in state could include waste generated from other processes that use biomass, such as from paper and pulp mills or municipal solid waste; however, for the removals to count for MA, the biomass would have to from MA. Quantifying what fraction of biomass used in these facilities are grown in MA is out of scope for this estimate.

Data:
- the amount of forestry waste, agricultural, and other wet waste in MA. Wet waste is given in dry tons.
- the conversion rate of biomass to tCO2 in the BECCS to electricity process

Assumptions:
- all forestry waste, agricultural waste, and other wet waste in MA are used for BECCS to electricity
- MA does not use purpose-grown crops to create biochar

BECCS to fuels

Scale potential (tCO2e/y)	
Low	112,738
High	1,007,248

Data				
Parameter	Value	Unit	Notes	Source
Agricultural wastes	21594	dry tons/y	Assumes agricultural waste (ag processing waste and ag residues) can be used for BECCS	https://bioenergykdf.ornl.gov/bt23-agricultural-download?f%5B0%5D=bt23_agricultural_scenario_facet%3Anear-term
Forestry wastes	47234	dry tons/y	Assumes forestry wastes (all included in the report except for small diameter trees) can be used for BECCS	https://bioenergykdf.ornl.gov/bt23-forestry-download?f%5B0%5D=bt23_forestry_scenario_name%3Anear-term
Other wet wastes	641449	dry tons/y	Assumes other wet waste (sludge, manure, and food waste) can be used for BECCS	https://bioenergykdf.ornl.gov/bt23-wastes-download?f%5B0%5D=bt23_subclass_facet%3AOther%20wet%20waste
Agricultural biomass conversion upper	2	tCO2e/ton		https://www.pnas.org/doi/10.1073/pnas.2217695120#:~:text=The%20weight%20fraction%20of%20carbon,deemed%20to%20be%20less%20controversial.
Agricultural biomass conversion lower	1.5	tCO2e/ton		https://www.pnas.org/doi/10.1073/pnas.2217695120#:~:text=The%20weight%20fraction%20of%20carbon,deemed%20to%20be%20less%20controversial.
Forestry waste conversion efficiency	1.72	tCO2e/ton	Uses the carbon fraction of forest biomass in the linked source and converts to CO2	Proposal to integrate AFOLU
Sludge conversion efficiency upper	1.63	tCO2e/ton	Assumes the high carbon content of sludge measured in the linked source and converts to CO2	Slow-pyrolysis of municipal sewage sludge: biochar characteristics and advanced thermodynamics
Sludge conversion efficiency lower	1.08	tCO2e/ton	Assumes the low carbon content of sludge measured in the linked source and converts to CO2	Slow-pyrolysis of municipal sewage sludge: biochar characteristics and advanced thermodynamics
BECCS conversion upper	0.9		Assumes high end of biomass conversion efficiency for the range of BECCS to fuels scenarios in the supplementary information of the linked source	CO2 mitigation or removal: The optimal uses of biomass in energy system decarbonization: iScience
BECCS conversion lower	0.14		Assumes low end of biomass conversion efficiency for the range of BECCS to fuels scenarios in the supplementary information of the linked source	CO2 mitigation or removal: The optimal uses of biomass in energy system decarbonization: iScience
Upper bound removal estimate	1007248	tCO2/y	Assumes high conversion efficieny and that all biomass waste is used for BECCS	Calculated
Lower bound removal estimate	112738	tCO2/y	Assumes low conversion efficieny and that all biomass waste is used for BECCS	Calculated

Explanation and assumptions:
BECCS to fuels annual CDR potential was calculated by assuming all biomass waste in MA across the forestry, agricultural, and wastewater industries are used to in the BECCS to fuels process. No purpose grown crops are included in the scale estimate. The estimate of available waste biomass generated in state could include waste generated from other processes that use biomass, such as from paper and pulp mills or municipal solid waste; however, for the removals to count for MA, the biomass would have to from MA. Quantifying what fraction of biomass used in these facilities are grown in MA is out of scope for this estimate.

Data:
- the amount of forestry waste, agricultural, and other wet waste in MA. Wet waste is given in dry tons.
- the conversion rate of biomass to tCO2 in the BECCS to electricity process

Assumptions:
- all forestry waste, agricultural waste, and other wet waste in MA are used for BECCS to fuels
- MA does not use purpose-grown crops to create biochar

Surficial mineralization

Scale potential (tCO2e/y)	
Low	653,696
High	1,257,108

Data				
Parameter	Value	Unit	Notes	Source
Ultramfic mine tailing production in MA	0	ton/y	MA produces sand and gravel for construction and crushed stone, but not minerals that create ultramafic taliings (i.e., nickel, chromium, titaniam, platinum group metals, diamonds, copper, and lead-zinc)	The Mineral Industry of Massachusetts | U.S. Geological Survey
Steel slag in MA	0	ton/y	Because there are no active steel facilities in MA, there is no access to steel slag	Slag Availability | National Slag Association
C&D waste in MA	1633936	ton/y	This is the amount of C&D waste processed by MA in 2024. This category is defined in the source to be building material and rubber, including concrete from construction and demolition. It also includes other materials, like brick and wood, which are not as suitable for carbonation. This is therefore an over-estimate of the C&D waste available for carbonation in MA.	CD report summary data
Coal ash in MA	304	ton/y	See supplemental calculation table below	Calculated
Total alkaline material production in MA	1634240	ton/y		Calculated
Brucite mineralization ratio	1.3	t brucite/tCO2	Assumes that the ultramafic waste in MA have a mineralization rate between that of brucite and wollastonite	Engineered carbon mineralization in ultramafic rocks for CO2 removal from air_ Review and new insights
Wollastonite mineralization ratio	2.5	t wollastonite/tCO2	Assumes that the ultramafic waste in MA have a mineralization rate between that of brucite and wollastonite	Engineered carbon mineralization in ultramafic rocks for CO2 removal from air_ Review and new insights
Upper bound removal estimate	1257108	tCO2e/y	Assumes fines have similar mineralization rate to most efficient mineral feedstock	Calculated
Lower bound removal estimate	653696	tCO2e/y	Assumes fines have similar mineralization rate to least efficient mineral feedstock	Calculated

Explanation and assumptions:
Surficial mineralization annual CDR potential was calculated by estimating the amount of suitable feedstock of the state produces and assuming it all goes to surficial mineralization. Suitable feedstock consists of ultrmafic mine tailings (of which MA has none), steel slag (of which MA has none), C&D (construction and demolition) waste, and coal ash.

Data:
- the amount of ultramafic mine tailings, steel slag, C&D waste, and coal ash in MA
- brucite and wollastonite mineralization rate

Assumptions:
- all ultramafic mine tailings, steel slag, C&D waste, and coal ash in MA are used for surficial mineralization
- the total amount of C&D waste processed by MA in 2024 is suitable for carbonation. In reality, this category of wastes includes other materials, like brick and wood, which are not as suitable for carbonation and is therefore an over-estimate of the C&D waste available for carbonation in MA.

Supplementary Data - Coal Ash				
Parameter	Value	Unit	Notes	Source
Historical coal plants in MA	6	number of facilities	6 historical coal plants, two of which had landfills or ponds for coal ash	Fact sheet
Historical coal plants in MA with EPA's CCR reports	2	number of facilities	Mt Tom Station Power Plant and Brayton Point	List of Publicly Accessible Internet Sites Hosting CCR Management Compliance Data and Information | US EPA
Historical coal plants in MA with EPA's CCR reports and legacy surface impoundments	1	number of facilities	Mt Tom Station Power Plant	List of Publicly Accessible Internet Sites Hosting CCR Management Compliance Data and Information | US EPA
Volume of coal ash at Mt Tom Station Power Plant	14200	cubic yards	As of the Jan 2025 inspection report, for its two coal ash basins	Mt-Tom-CCR-Initial-Inspection-Report.pdf
Density of coal ash	700	kg/m3	Average bulk density with no compaction	Fly Ash, Slag, Silica Fume, and Natural Pozzolans, Chapter 3
Cubic yards to cubic meter conversion	0.765	yd3/m3		
Volume of coal ash at Mt Tom Station Power Plant	10863	m3		
Coal ash at Mt Tom Station Power Plant	7604	ton		Calculated
Lifetime of coal ash CDR project	25	years	Assuming coal ash is used for CDR from now until 2050	
Coal ash in MA	304	ton/y		Calculated

Terrestrial enhanced weathering

Scale potential (tCO2e/y)	
Low	3,115,719
High	11,683,946

Data				
Parameter	Value	Unit	Notes	Source
Amount of farmland in MA	464451	acres	Amount of farmland is based on the USDA 2022 Census of Agriculture	Agricultural Resources Facts and Statistics | Mass.gov
Amount of forested land in MA	2981441	acres	Although less commonly done commercially, research is progressing on applying EW to forests (https://www.sciencedirect.com/science/article/pii/S0301479725033110) and so MA could apply TEW to their forested land in addition to their farmland	Forests of Massachusetts, 2021: FIA annual snapshot.
Application rate of alkaline mineral (based on farmland application)	6.7	t feedstock per ha	Application rate on a field trial in Massachusetts. This is based on basalt fines application to farmland. This rate is assumed to apply to all feedstock and all suitable land (farmland and forested land)	Basalt Rock Dust Amendment on Soil Health Properties and Inorganic Nutrients—Laboratory and Field Study at Two Organic Farm Soils in New England, USA
			This source offers an additional range of tCO2 per ha on US agriculture, which aligns with what is calculated using the MA field trial	Transforming US agriculture for carbon removal with enhanced weathering | Nature
Reference application rate for forested land	5	t feedstock per ha	Application rate of wollastonite-rich rock powder on forested land in Canada; aligns with the magnitude of application rate used here	Incorporating enhanced rock weathering into sustainable forest management - ScienceDirect
Upper bound of mineralization rate	0.8	ton feedstock/t CO2	Assumes high end of range	Frontiers | Geochemical Negative Emissions Technologies: Part I. Review
Lower bound of mineralization rate	3	ton/tCO2	Assumes low end of range	Frontiers | Geochemical Negative Emissions Technologies: Part I. Review
Reference removal rate per ha	3.4	tCO2/ha/y	Removal rate from field trials of basalt, fits within the range presented here	Enhanced weathering in the US Corn Belt delivers carbon removal with agronomic benefits
Amount of farmland in MA	188037	ha	Unit conversion, 1 ha is 2.47 acres	Conversion
Amount of forested land in MA	1207061	ha	Unit conversion, 1 ha is 2.47 acres	Conversion
Upper bound removal estimate - farmland	1574809	tCO2e/y	Assumes all farmland is used for TEW and high CO2 uptake by alkaline minerals	Calculated
Lower bound removal estimate - farmland	419949	tCO2e/y	Assumes all farmlandland is used for TEW and low CO2 uptake by alkaline minerals	Calculated
Upper bound removal estimate - forested land	10109137	tCO2e/y	Assumes all forested land is used for TEW and high CO2 uptake by alkaline minerals	Calculated
Lower bound removal estimate - forested land	2695770	tCO2e/y	Assumes all forested land is used for TEW and low CO2 uptake by alkaline minerals	Calculated
Upper bound removal estimate	11683946	tCO2e/y	Assumes all farmland and forested land is used for TEW and high CO2 uptake by alkaline minerals	Calculated
Lower bound removal estimate	3115719	tCO2e/y	Assumes all farmland and forested land is used for TEW and low CO2 uptake by alkaline minerals	Calculated

Explanation and assumptions:
Terrestrial enhanced weathering (TEW) annual CDR potential was calculated by estimating the amount of available farmland and forested area in MA and assuming TEW is applied on all of it. Because MA could import alkaline minerals and the removal would still happen on MA land, available suitable land is the constraining factor in this estimate.

Data:
- the amount of farmland in MA
- the amount of forested area in MA
- the application rate of basalt fines in a MA field trial
- the mineralization rate of alkaline materials

Assumptions:
- all farmland in MA is used for TEW
- all forested area in MA is used for TEW
- the application rate from a MA field trial for basalt applies to all feedstock and all suitable land (farmland and forested land)

Coastal enhanced weathering

Scale potential (tCO_2e/y)	
Low	42,176
High	100,078

Data				
Parameter	Value	Unit	Notes	Source
MA coastline	575	miles	Informed by MA state government expert review, based on the linked source	Massachusetts Coastal Erosion Commission | Mass.gov
Shoreline width	0.06	miles	Informed by MA state government expert review, based on the linked source	Massachusetts Coastal Erosion Commission | Mass.gov
Beach / shoreline area	34.5	square miles		Calculated
Square miles to square meters conversion	2,590,000	m2 / square mile		Conversion
Acres to square meters conversion	4047	m2 / acre		Conversion
Total beach area	89,355,000	m2		Calculated
Mineral additions per area (lower)	0.59	kg/m2 land	Assumes low range	https://pubs.acs.org/doi/10.1021/acs.est.2c08633
Mineral additions per area (upper)	1.4	kg/m2 land	Assumes high range	https://pubs.acs.org/doi/10.1021/acs.est.2c08633
tCO2e/ton of olivine	1.25	ton/tCO2e		Negative Emissions Technologies and Reliable Sequestration: A Research Agenda | The National Academies Press
Upper bound of removal potential - beach	100,078	tCO2e/y	Assumes high mineral addition rate	Calculated
Lower bound of removal potential - beach	42,176	tCO2e/y	Assumes low mineral addition rate	Calculated
Upper bound of removal potential	100,078	tCO2e/y	Assumes high mineral addition rate	Calculated
Lower bound of removal potential	42,176	tCO2e/y	Assumes low mineral addition rate	Calculated

Explanation and assumptions:
Coastal enhanced weathering (CEW) annual CDR potential was calculated by estimating the amount of available beach area in MA and assuming CEW is applied on all of it. Because MA could import alkaline minerals and the removal would still happen on MA land, application area is the constraining factor in this estimate.

Data:
- the amount of coastline in MA
- the application rate of minerals in academic studies
- the mineralization rate of olivine

Assumptions:
- all beach area in MA is used for CEW
- shorelines are 0.06 miles wide

Mineral alkalinity enhancement

Scale potential (tCO_2e/y)	
Low	1,551,797
High	2,069,063

Data				
Parameter	Value	Unit	Notes	Source
Territorial Sea + Coastal Water Zone Area	2269	sq miles	Assumes all territorial sea and coastal water can be utilized and is fit for deployment	State Area Measurements and Internal Point Coordinates https://www2.census.gov/geo/pdfs/reference/GARM/Ch15GARM.pdf
Conversion sq mi to m2	2589988	m2 / sq mi	N/A	Conversions
Total eligible area for TSCW zone approach	5876683022	sq meters	Assumes all sea area under MA jursidiction can be used for MAE	Calculated
Application rate	10	mol/m2/y	As per footnote 11 in this source, assumes this application rate does not change pH more than 0.1 and therefore there is not a risk of carbonate precipitation	Mapping the efficiency of ocean alkalinity enhancement – CarbonPlan
			Paper referenced in footnote 11	BG - Limits and CO2 equilibration of near-coast alkalinity enhancement
mole CO2 to mole alkalinity - low	0.6	mol/mol	Assumes an average efficiency of 0.7 for Region 17 of the tool, and adds +/- 0.1 to get a range	OAE Efficiency – CarbonPlan
mole CO2 to mole alkalinity - high	0.8	mol/mol	This range also aligns with the effiencies across seasons in Fig 2 b of this source	Mapping the global variation in the efficiency of ocean alkalinity enhancement for carbon dioxide removal | Nature Climate Change
molar mass of CO2	44.01	g/mol		Conversions
grams to tonne conversion	1000000	g/ton		Conversions
mole CO2 to t CO2 conversion	0.00004401	tons per mol CO2		Calculated

Explanation and assumptions:
Mineral alkalinity enhancement (MAE) annual CDR potential was calculated by constraining the rate of alkalinity addition to prevent secondary carbonate precipitation. This estimate assumes that MA only adds alkalinity to the waters that it has jurisdiction over.

Data:
- the ocean area in MA's territorial sea and coastal waters
- the alkalinity application rate that does not have a risk of carbonate precipitation
- the mole CO2 removed to mole alkalinity added ratio

Assumptions:
- all sea area under MA jursidiction can be used for MAE

Lower bound of removal potential	1551797	tCO2e/y	Assumes alkalinity application only over terretorial sea area, low CO2 to alkalinity efficiency, and an application rate of 10 mol alkalinity per m2 per year	Calculated
Upper bound of removal potential	2069063	tCO2e/y	Same as above, except assumes a high CO2 to alkalinity efficiency	Calculated

CO2 stripping

Scale potential (tCO2e/y)	
Low	1,551,797
High	2,069,063

Data				
Parameter	Value	Unit	Notes	Source
Projected annual electricity demand in 2050	138.2	TWh		https://www.mass.gov/info-details/massachusetts-clean-energy-and-climate-plan-for-2050
15% of projected electricity demand in 2050	20.73	TWh	Assumes an additional 15% (in line with GHG limits) of clean energy demand projected for 2050 can be created and dedicated to CO2 stripping in MA	Calculated
Current total annual clean energy production in MA	868000	MWh	Reference number	Massachusetts Profile
Energy Requirement per tCO2 - low	1.5	MWh / tCO2		A Research Strategy for Ocean Carbon Dioxide Removal and Sequestration
Energy Requirement per tCO2 - high	3.1	MWh / tCO2		A Research Strategy for Ocean Carbon Dioxide Removal and Sequestration
Upper bound of removal potential - electricity constraint	13820000	tCO2e/y	Assumes CO2 stripping uses all of the dedicated 15% of energy and low energy requirement	Calculated
Lower bound of removal potential - electricity constraint	6687097	tCO2e/y	Assumes CO2 stripping uses all of the dedicated 15% of energy and high energy requirement	Calculated
Lower bound of removal potential - base addition constraint	1551797	tCO2e/y	Same as MAE, based on the constraint of the addition of base to the ocean	Calculated
Upper bound of removal potential - base addition constraint	2069063	tCO2e/y	Same as MAE, based on the constraint of the addition of base to the ocean	Calculated

Explanation and assumptions:
CO2 stripping annual CDR potential was calculated by constraining the rate of base addition to prevent secondary carbonate precipitation. This estimate assumes that MA only adds base to the waters that it has jurisdiction over. For more details on this calculation, see Mineral alkalinity enhancement.

An additional scale estimate was created using clean electricity as the constraining factor, but this estimate was greater than the scale potential if limited by the rate of base addition.

The scale potential of CO2 stripping will also depend on available CO2 storage, which in MA will likely be ex-situ mineralization.

Data:
- the ocean area in MA's territorial sea and coastal waters
- the base addition rate does not have a risk of carbonate precipitation
- the mole CO2 removed to mole base added ratio
- the energy requirement for CO2 stripping

Assumptions:
- the future electricity demand in MA aligns with projections
- all CO2 removed by CO2 stripping can be stored

Electrochemical alkalinity production

Scale potential (tCO2e/y)	
Low	1,551,797
High	2,069,063

Data				
Parameter	Value	Unit	Notes	Source
Projected annual electricity demand in 2050	138.2	TWh		https://www.mass.gov/info-details/massachusetts-clean-energy-and-climate-plan-for-2050
15% of projected electricity demand in 2050	20.73	TWh	Assumes an additional 15% (in line with GHG limits) of clean energy demand projected for 2050 can be created and dedicated to EAP in MA	Calculated
Current total annual clean energy production in MA	868000	MWh	Reference number	Massachusetts Profile
Upper bound of Energy Requirement per tCO2	4.4	MWh / tCO2	Assumes lowest energy efficiency for EAP	PowerPoint Presentation
Lower bound of Energy Requirement per tCO2	2	MWh / tCO2	Assumes high energy efficiency for EAP	PowerPoint Presentation
Upper bound of removal potential - electricity constraint	10365000	tCO2e/y	Assumes highest energy efficiency is used for all EAP and EAP uses all of the dedicated 15% of energy	Calculated
Lower bound of removal potential - electricity constraint	4711364	tCO2e/y	Assumes lowest energy efficiency is used for all EAP and EAP uses all of the dedicated 15% of energy	Calculated
Lower bound of removal potential - alkalinity application constraint	1551797	tCO2e/y	Same as MAE, based on the constraint of the addition of alkalinity to the ocean	Calculated
Upper bound of removal potential - alkalinity application constraint	2069063	tCO2e/y	Same as MAE, based on the constraint of the addition of alkalinity to the ocean	Calculated

Explanation and assumptions:
Electrochemical alkalinity production (EAP) annual CDR potential was calculated by constraining the rate of alkalinity addition to prevent secondary carbonate precipitation. This estimate assumes that MA only adds alkalinity to the waters that it has jurisdiction over. For more details on this calculation, see Mineral alkalinity enhancement.

An additional scale estimate was created using clean electricity as the constraining factor, but this estimate was greater than the scale potential if limited by the rate of alkalinity addition.

Data:
- the ocean area in MA's territorial sea and coastal waters
- the alkalinity application rate that does not have a risk of carbonate precipitation
- the mole CO2 removed to mole alkalinity added ratio
- the energy requirement for EAP

Assumptions:
- the future electricity demand in MA aligns with projections

Direct air capture

Scale potential (tCO2e/y)	
Low	6,784,364
High	14,925,600

Data				
Parameter	Value	Unit	Notes	Source
Projected electricity demand in 2050	138.2	TWh		https://www.mass.gov/info-details/massachusetts-clean-energy-and-climate-plan-for-2050
15% of projected electricity demand in 2050	20.73	TWh	Assumes an additional 15% (in line with GHG limits) of clean energy demand projected for 2050 can be created and dedicated to DAC in MA	Calculated
Total Clean Energy Production in MA	868000	MWh	Reference number	Massachusetts Profile
Upper bound of Energy Requirement per tCO2	3.1	MWh / tCO2	Assumes lowest energy efficiency for DAC	PowerPoint Presentation
Lower bound of Energy Requirement per tCO2	1.4	MWh / tCO2	Assumes high energy efficiency for DAC	PowerPoint Presentation
Upper bound of removal potential	14925600	tCO2e/y	Assumes highest energy efficiency is used for all DAC and DAC uses all of the dedicated 15% of energy	Calculated
Lower bound of removal potential	6784364	tCO2e/y	Assumes lowest energy efficiency is used for all DAC and DAC uses all of the dedicated 15% of energy	Calculated

Explanation and assumptions:
Direct air capture (DAC) annual CDR potential was calculated by using clean electricity in MA as the constraining factor. The amount of available clean electricity is based on electricity demand projections and MA's climate goals.

The scale potential of CO2 stripping will also depend on available CO2 storage, which if done within MA would likely be ex-situ mineralization.

Data:
- the energy requirement for DAC

Assumptions:
- the future electricity demand in MA aligns with projections
- 15% of clean electricity can be dedicated to DAC
- all CO2 removed by DAC can be stored

Conventional CO2 storage

Scale potential (tCO2e/y)	
Low	0
High	0

Data				
Parameter	Value	Unit	Notes	Source
Onshore geologic storage in MA	0	sites	N/A	N/A

Explanation and assumptions:
Because of the lack of known, suitable conventional geologic storage in MA, the scale potential estimate is zero.

In-situ mineralization

Scale potential (tCO2e/y)	
Low	0
High	0

Data				
Parameter	Value	Unit	Notes	Source
Suitable rock formations onshore in MA	0	sites	N/A	N/A

Explanation and assumptions:
Because of the lack of known, suitable mineralization storage in MA, the scale potential estimate is zero.

Ex-situ mineralization

Scale potential (tCO2e/y)	
Low	N/A
High	19,527,200

Data				
Parameter	Value	Unit	Notes	Source
Aggregates produced in Massachusetts	44,380,000	t/y	Assumes all aggregate produced in MA can be replaced by aggregate produced using ex-situ mineralization	https://www.usgs.gov/media/files/usgs-aggregates-time-series-data-state-type-and-end-use
CO2e/mineral aggregate	440	kgCO2e/t mineral aggregate	Assume conversion ratio of all ex-situ mineralization is similar to Blue Planet's process	https://www.blueplanetsystems.com/
ton CO2e / mineral aggregate	0.44	tCO2e/ t mineral aggregate		Calculated
Removal potential estimate	19,527,200	tCO2e/y	Assumes all aggregate produced in MA can be replaced by aggregate produced using ex-situ mineralization	Calculated

Explanation and assumptions:
Ex-situ mineralization annual CDR potential was calculated by assuming all aggregate currently productedin MA is used to store CO2.

Data:
- the amount of aggregate produced in MA
- the carbon storage capacity of aggregate

Assumptions:
- all aggregate production in produced by MA is used for ex-situ mineralization

R&D jobs

Data				
Parameter	Value	Unit	Notes	Source
Percentage of jobs that are R&D - low	0.05		Assumes a large company (25,000 or more, of which 5% are R&D)	NSF 25-327 Table 6
Percentage of jobs that are R&D - high	0.4		Assume a small company (10-19 employees, of which 40% are R&D)	NSF 25-327 Table 6

Note on R&D job calculations:
Across all CDR approaches, the number of R&D jobs was calculated by assuming that a fixed percentage of jobs for a company are R&D jobs. A low and high estimate are created by assuming a large company (25,000 or more, of which 5% are R&D) and assuming a small company (10-19 employees, of which 40% are R&D), percentages which are taken from an NSF report.

With this method of calculation, a pathway's R&D jobs depend on the scale of deployment in Massachusetts. This may not necessarily be true, because R&D jobs for a pathway can occur in Massachusetts even if deployment is happening globally. Research and development jobs may more likely be determined by the State's investment and support for CDR innovation and commercialization.

Forests

Job creation rate (jobs/Mtpa)	
R&D - low	1
R&D - high	1,021
Construction - low	-
Construction - high	-
O&M - low	-
O&M - high	-
Total (w/o R&D) - low	26
Total (w/o R&D) - high	2,552
Total - low	27
Total - high	3,573

Data				
Parameter	Value	Unit	Notes	Source
Jobs per dollar invested - low	25.7	jobs/$1 million	Estimated for reforestation in urban settings	Key-Log-Economics-Memo_Potential-Employment-Impacts-of-Reforestation-Investments-May-2020.pdf
Jobs per dollar invested - high	31.9	jobs/$1 million	Estimated for reforestation in rural settings	Key-Log-Economics-Memo_Potential-Employment-Impacts-of-Reforestation-Investments-May-2020.pdf
Forestry credit cost - low	1	$/tCO2		Independent Review of Greenhouse Gas Removals
Forestry credit cost - high	80	$/tCO2		What Makes Forest Project a High-Quality Carbon Removal?

Explanation and assumptions:
The job creation potential of forests was calculated by using data on the jobs created for reforestation per million dollars invested and a range of forestry credit costs. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per million dollar invested for reforestation
- percentage of employees that are R&D for various company sizes
- cost of a forestry credit

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

Agricultural soils

Job creation rate (jobs/Mtpa)	
R&D - low	28
R&D - high	295
Construction - low	-
Construction - high	-
O&M - low	550
O&M - high	738
Total (w/o R&D) - low	550
Total (w/o R&D) - high	738
Total - low	578
Total - high	1,033

Data				
Parameter	Value	Unit	Notes	Source
TEW O&M jobs - low	1,100	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
TEW O&M jobs - high	1,475	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Percentage of TEW O&M jobs that can be analogized to agricultural soils	0.5		Assumes MRV jobs but not transportation jobs are relevant	Independent Review of Greenhouse Gas Removals

Explanation and assumptions:
The job creation potential of agricultural soils is difficult to quantify due to additionality. For example, while soil practices would require farm labor to implement, they would likely be done by existing farmers and so no additional jobs would be created. Additional jobs could come from any additional labor needed to perform sampling and measurement, as well as any induced supply chain jobs from measurment and other equipment. Data on this is not widely available.

As a proxy, the job creation estimates for terrestrial enhanced weathering (TEW) were used as a basis here (see TEW section below for more details). The MRV process of TEW, which creates O&M jobs, is analogous to agricultural soils. However, because TEW O&M jobs also include transportation of delivering mineral to farms, O&M jobs created by agricultural soils was assumed to be 50% of O&M jobs created by TEW.

The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa for O&M jobs for TEW

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)
- O&M jobs for agricultural soils are half of O&M jobs created for TEW

Salt marshes

Job creation rate (jobs/Mtpa)	
R&D - low	16
R&D - high	540
Construction - low	-

Data				
Parameter	Value	Unit	Notes	Source
Jobs per dollar invested - low	13.0	jobs/$1 million		https://www.noaa.gov/reports/noaa-coastal-management-habitat-restoration-investments
Jobs per dollar invested - high	30.0	jobs/$1 million		https://www.fisheries.noaa.gov/feature-story/habitat-restoration-supports-jobs-stewardship

Explanation and assumptions:
The job creation potential of salt marshes was calculated by using data on the jobs created for salt marsh restoration per million dollar invested and a range of salt marsh credit costs. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per million dollars invested for salt marsh restoration
- percentage of employees that are R&D for various company sizes
- cost of a salt marsh credit

Construction - high	-
O&M - low	-
O&M - high	-
Total (w/o R&D) - low	325
Total (w/o R&D) - high	1,350
Total - low	341
Total - high	1,890

Salt marsh credit cost - low	25	$/tCO2		Greenhouse gas removal methods and their potential UK deployment
Salt marsh credit cost - high	45	$/tCO2		Greenhouse gas removal methods and their potential UK deployment

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

Biomass direct storage

Job creation rate (jobs/Mtpa)	
R&D - low	60
R&D - high	600
Construction - low	-
Construction - high	-
O&M - low	-
O&M - high	-
Total (w/o R&D) - low	1,200
Total (w/o R&D) - high	1,500
Total - low	1,260
Total - high	2,100

Data				
Parameter	Value	Unit	Notes	Source
Total jobs - low	1,200	jobs/Mtpa	Internal modeleing, based on company interviews done for the linked source; excludes R&D	Scaling Technological Greenhouse Gas Removal: A Global Roadmap to 2050 - RMI
Total jobs - high	1,500	jobs/Mtpa	Internal modeleing, based on company interviews done for the linked source; excludes R&D	Scaling Technological Greenhouse Gas Removal: A Global Roadmap to 2050 - RMI

Explanation and assumptions:
The job creation potential of biomass direct storage was taken from RMI internal modeling and company interviews. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa from company interviews

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

Timber building products

Job creation rate (jobs/Mtpa)	
R&D - low	193
R&D - high	5,606
Construction - low	-
Construction - high	-
O&M - low	-
O&M - high	-
Total (w/o R&D) - low	3,857
Total (w/o R&D) - high	14,014
Total - low	4,050
Total - high	19,620

Data				
Parameter	Value	Unit	Notes	Source
m3 of wood per t removal - low	0.3	m3/tCO2		PowerPoint Presentation
m3 of wood per t removal - high	1.1	m3/tCO2		PowerPoint Presentation
jobs per million cubic feet of timber	360	jobs/MMCF	In the Northeast	JournalForestryJul2016.pdf
Cubic feet to cubic meter	0.028		1 cubic feet is 0.028 cubic meters	Conversion
m3 of wood per t removal - low	10.7	ft3/tCO2		Conversion
m3 of wood per t removal - high	38.9	ft3/tCO2		Conversion
Total jobs - low	3,857	jobs/Mtpa	Excluding R&D	Calculated
Total jobs - high	14,014	jobs/Mtpa	Excluding R&D	Calculated

Explanation and assumptions:
The job creation potential of timber building products was calculated by using the number of jobs created per unit of timber and the amount of CO2 removed by unit of timber. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- the amount of CO2 removed by unit of timber
- the number of jobs created per unit of timber

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

Other biomass building products

Job creation rate (jobs/Mtpa)	
R&D - low	78
R&D - high	796
Construction - low	-
Construction - high	-
O&M - low	-

Data				
Parameter	Value	Unit	Notes	Source
Average direct (manufacturing) jobs per m3 of bio-based product	0.0003	jobs/m3	From data source in Appendix B of linked source	https://rmi.org/wp-content/uploads/dlm_uploads/2025/04/building_with_biomass_a_new_american_harvest.pdf
Average bio-based product density	408.5	kg/m3	From data source in Appendix B of linked source	https://rmi.org/wp-content/uploads/dlm_uploads/2025/04/building_with_biomass_a_new_american_harvest.pdf
kg to tons conversion	1000		1000 kgs are in 1 metric ton	Conversion
Average bio-based product density	0.41	ton/m3	1 cubic feet is 0.028 cubic meters	Conversion

Explanation and assumptions:
The job creation potential of other biomass building products was calculated by dividing the jobs created into two categories of additional jobs: 1) jobs created by the manufacturing of the materials and 2) jobs created by the need to harvest biomass residues, which is assumed to be the same as the jobs needed for biomass direct storage. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- the amount of CO2 removed by by biomass
- the number of jobs created per unit of bio-based building product
- the average bio-based product density

Assumptions
- the jobs created for the harvesting of biomass waste and residues for biomass building products is the same as the jobs created for biomass direct storage
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

O&M - high	-
Total (w/o R&D) - low	1,567
Total (w/o R&D) - high	1,990
Total - low	1,646
Total - high	2,785

Biomass to CO2 conversion - high	2	tCO2e/ton		https://www.pnas.org/doi/10.1073/pnas.2217695120#:~:text=The%20weight%20fraction%20of%20carbon,deemed%20to%20be%20less%20controversial.
Biomass to CO2 conversion - low	1.5	tCO2e/ton		https://www.pnas.org/doi/10.1073/pnas.2217695120#:~:text=The%20weight%20fraction%20of%20carbon,deemed%20to%20be%20less%20controversial.
Total direct jobs - high	490	jobs/Mtpa	Excluding R&D	Calculated
Total direct jobs - low	367	jobs/Mtpa	Excluding R&D	Calculated
Total biomass waste harvesting jobs - high	1,500	jobs/Mtpa	Excluding R&D. same as biomass direct storage	
Total biomass waste harvesting jobs - low	1,200	jobs/Mtpa	Excluding R&D. same as biomass direct storage	

Pyrolysis (biochar) and storage

Job creation rate (jobs/Mtpa)	
R&D - low	65
R&D - high	720
Construction - low	550
Construction - high	750
O&M - low	750
O&M - high	1,050
Total (w/o R&D) - low	1,300
Total (w/o R&D) - high	1,800
Total - low	1,365
Total - high	2,520

Data				
Parameter	Value	Unit	Notes	Source
O&M jobs - low	750	jobs/Mtpa	Assumes the same types of jobs are needed for biochar as for bioliquid	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
O&M jobs - high	1,050	jobs/Mtpa	Assumes the same types of jobs are needed for biochar as for bioliquid	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - low	550	jobs/Mtpa	Assumes the same types of jobs are needed for biochar as for bioliquid	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - high	750	jobs/Mtpa	Assumes the same types of jobs are needed for biochar as for bioliquid	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf

Explanation and assumptions:
The job creation potential of apyrolysis (biochar) and storage is calculated by assuming the job creation magnitude and types of jobs creation for pyrolysis (bioliquid) and storage are similar to the job creation profile of pyrolysis (biochar) and storage. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa for jobs for pyrolysis (bioliquid) and storage

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)
- job creation profile for biochar is the same as bioliquid

Pyrolysis (bioliquid) and storage

Job creation rate (jobs/Mtpa)	
R&D - low	65
R&D - high	720
Construction - low	550
Construction - high	750
O&M - low	750
O&M - high	1,050
Total (w/o R&D) - low	1,300
Total (w/o R&D) - high	1,800
Total - low	1,365
Total - high	2,520

Data				
Parameter	Value	Unit	Notes	Source
O&M jobs - low	750	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
O&M jobs - high	1,050	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - low	550	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - high	750	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf

Explanation and assumptions:
The job creation potential of pyrolysis (bioliquid) and storage is taken from an existing report by the Rhodium Group. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa for jobs for pyrolysis (bioliquid) and storage

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

Microalgae in ponds

Job creation rate (jobs/Mtpa)

Data

Explanation and assumptions:

R&D - low	17
R&D - high	557
Construction - low	-
Construction - high	-
O&M - low	-
O&M - high	-
Total (w/o R&D) - low	330
Total (w/o R&D) - high	1,391
Total - low	347
Total - high	1,948

Parameter	Value	Unit	Notes	Source
Jobs needed per acre of pond	0.02	jobs/acre	Estimated from a raceway pond set-up in the linked source, of a total pond area od 5,00 acres, divided into 10-acre ponds. This requires 100 employees.	Process Design and Economics for the Production of Algal Biomass: Algal Biomass Production in Open Pond Systems and Processing Through Dewatering for Downstream Conversion
Average annual microalgae production of ponds - low (open ponds)	23.7	t algae per ha per year	See Microalgae in ponds, Scale Calculations tab for more details	Calculated
Average annual microalgae production of ponds - high (flat panel PBR)	74.8	t algae per ha per year	See Microalgae in ponds, Scale Calculations tab for more details	Calculated
Biomass conversion upper	2	tCO2e/ton		https://www.pnas.org/doi/10.1073/pnas.2217695120#:~:text=The%20weight%20fraction%20of%20carbon,deemed%20to%20be%20less%20controversial.
Biomass conversion lower	1.5	tCO2e/ton		https://www.pnas.org/doi/10.1073/pnas.2217695120#:~:text=The%20weight%20fraction%20of%20carbon,deemed%20to%20be%20less%20controversial.
Jobs needed per hectare of pond	0.05	jobs/ha	2.47 acres in 1 ha	Conversion
Total jobs - low	330	jobs/Mtpa		Calculated
Total jobs - high	1,391	jobs/Mtpa		Calculated

The job creation potential of microalgae in open water was based on modeling done by NREl for open raceway ponds, which estimates the employees needed for 5,000 acres of pond area divided into 10 acre ponds. Using conversions of the pond area to algal production, the number of jobs can be calcualated. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per acre of pond area
- biomass conversion efficiencies

Assumptions
- the jobs per acre NREL modeling holds true for microalgae in ponds facilities in MA
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

Microalgae in open water

Job creation rate (jobs/Mtpa)	
Total - low	N/A
Total - high	N/A

Data				
Parameter	Value	Unit	Notes	Source
N/A	N/A	N/A	N/A	N/A

Explanation and assumptions:
Microalgae cultivation in open water is too early-stage and has too many uncertainties to estimate job creation potential in Massachusetts.

Macroalgae in open water

Job creation rate (jobs/Mtpa)	
R&D - low	25
R&D - high	280
Construction - low	-
Construction - high	-
O&M - low	-
O&M - high	-
Total (w/o R&D) - low	500
Total (w/o R&D) - high	700
Total - low	525
Total - high	980

Data				
Parameter	Value	Unit	Notes	Source
Total jobs - low	500	jobs/Mtpa	Internal modeleing, based on company interviews done for the linked source; excludes R&D	Scaling Technological Greenhouse Gas Removal: A Global Roadmap to 2050 - RMI
Total jobs - high	700	jobs/Mtpa	Internal modeleing, based on company interviews done for the linked source; excludes R&D	Scaling Technological Greenhouse Gas Removal: A Global Roadmap to 2050 - RMI

Explanation and assumptions:
The job creation potential of macroalgae in open water was taken from RMI internal modeling and company interviews. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa from company interviews

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

BECCS to electricity

Job creation rate (jobs/Mtpa)	
R&D - low	65
R&D - high	720
Construction - low	550

Data				
Parameter	Value	Unit	Notes	Source
O&M jobs - low	750	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
O&M jobs - high	1,050	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf

Explanation and assumptions:
The job creation potential of BECCS to electricity is taken from an existing report by the Rhodium Group. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa for jobs for BECCS

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

Construction - high	750
O&M - low	750
O&M - high	1,050
Total (w/o R&D) - low	1,300
Total (w/o R&D) - high	1,800
Total - low	1,365
Total - high	2,520

Construction jobs - low	550	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - high	750	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf

BECCS to fuels

Job creation rate (jobs/Mtpa)	
R&D - low	65
R&D - high	720
Construction - low	550
Construction - high	750
O&M - low	750
O&M - high	1,050
Total (w/o R&D) - low	1,300
Total (w/o R&D) - high	1,800
Total - low	1,365
Total - high	2,520

Data				
Parameter	Value	Unit	Notes	Source
O&M jobs - low	750	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
O&M jobs - high	1,050	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - low	550	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - high	750	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf

Explanation and assumptions:
The job creation potential of BECCS to fuels is taken from an existing report by the Rhodium Group. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa for jobs for BECCS

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

Surficial mineralization

Job creation rate (jobs/Mtpa)	
R&D - low	61
R&D - high	650
Construction - low	125
Construction - high	150
O&M - low	1,100
O&M - high	1,475
Total (w/o R&D) - low	1,225
Total (w/o R&D) - high	1,625
Total - low	1,286
Total - high	2,275

Data				
Parameter	Value	Unit	Notes	Source
O&M jobs - low	1,100	jobs/Mtpa	Assumes the same job creation profile as terrestrial enhanced weathering	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
O&M jobs - high	1,475	jobs/Mtpa	Assumes the same job creation profile as terrestrial enhanced weathering	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - low	125	jobs/Mtpa	Assumes the same job creation profile as terrestrial enhanced weathering	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - high	150	jobs/Mtpa	Assumes the same job creation profile as terrestrial enhanced weathering	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf

Explanation and assumptions:
The job creation potential of surficial mineralization is taken from an existing report by the Rhodium Group, assuming a similar job creation profile as terrestrial enhanced weathering. Making this assumption implies that the surficial mineralization process will include operators using industrial equipment to spread out alkaline minerals and to measure and monitor CO_2 uptake. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa for jobs for terrestrial enhanced weathering

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)
- the surficial mineralization process will include operators using industrial equipment to spread out alkaline minerals and to measure and monitor CO_2 uptake

Terrestrial enhanced weathering

Job creation rate (jobs/Mtpa)	
R&D - low	61

Data				
Parameter	Value	Unit	Notes	Source

Explanation and assumptions:
The job creation potential of terrestrial enhanced weathering is taken from an existing report by the

R&D - high	650
Construction - low	125
Construction - high	150
O&M - low	1,100
O&M - high	1,475
Total (w/o R&D) - low	1,225
Total (w/o R&D) - high	1,625
Total - low	1,286
Total - high	2,275

O&M jobs - low	1,100	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
O&M jobs - high	1,475	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - low	125	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - high	150	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf

Rhodium Group. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa for jobs for terrestrial enhanced weathering

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

Coastal enhanced weathering

Job creation rate (jobs/Mtpa)	
R&D - low	61
R&D - high	650
Construction - low	125
Construction - high	150
O&M - low	1,100
O&M - high	1,475
Total (w/o R&D) - low	1,225
Total (w/o R&D) - high	1,625
Total - low	1,286
Total - high	2,275

Data				
Parameter	Value	Unit	Notes	Source
O&M jobs - low	1,100	jobs/Mtpa	Assumes the same job creation profile as terrestrial enhanced weathering	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
O&M jobs - high	1,475	jobs/Mtpa	Assumes the same job creation profile as terrestrial enhanced weathering	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - low	125	jobs/Mtpa	Assumes the same job creation profile as terrestrial enhanced weathering	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - high	150	jobs/Mtpa	Assumes the same job creation profile as terrestrial enhanced weathering	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf

Explanation and assumptions:
The job creation potential of coastal enhanced weathering is taken from an existing report by the Rhodium Group, assuming a similar job creation profile as terrestrial enhanced weathering.The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa for jobs for terrestrial enhanced weathering

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)
- the coastal enhanced weathering process creates a similar job profile to terrestrialenhanced weathering

Mineral alkalinity enhancement

Job creation rate (jobs/Mtpa)	
R&D - low	44
R&D - high	470
Construction - low	225
Construction - high	300
O&M - low	650
O&M - high	875
Total (w/o R&D) - low	875
Total (w/o R&D) - high	1,175
Total - low	919
Total - high	1,645

Data				
Parameter	Value	Unit	Notes	Source
O&M jobs - low	650	jobs/Mtpa	Referred to as OAE in the linked source	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
O&M jobs - high	875	jobs/Mtpa	Referred to as OAE in the linked source	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - low	225	jobs/Mtpa	Referred to as OAE in the linked source	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - high	300	jobs/Mtpa	Referred to as OAE in the linked source	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf

Explanation and assumptions:
The job creation potential of mineral alkalinity enhancement is taken from an existing report by the Rhodium Group, where it is referred to as part of OAE. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa for jobs for ocean alkalinity enhancement

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

CO2 stripping

Job creation rate (jobs/Mtpa)	
R&D - low	29
R&D - high	330
Construction - low	325
Construction - high	450
O&M - low	250
O&M - high	375
Total (w/o R&D) - low	575
Total (w/o R&D) - high	825
Total - low	604
Total - high	1,155

Data				
Parameter	Value	Unit	Notes	Source
O&M jobs - low	250	jobs/Mtpa	Referred to as DOC in the linked source	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
O&M jobs - high	375	jobs/Mtpa	Referred to as DOC in the linked source	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - low	325	jobs/Mtpa	Referred to as DOC in the linked source	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - high	450	jobs/Mtpa	Referred to as DOC in the linked source	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf

Explanation and assumptions:
The job creation potential of CO2 stripping is taken from an existing report by the Rhodium Group, where it is referred to as DOC. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa for jobs for DOC

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

Electrochemical alkalinity enhancement

Job creation rate (jobs/Mtpa)	
R&D - low	44
R&D - high	470
Construction - low	225
Construction - high	300
O&M - low	650
O&M - high	875
Total (w/o R&D) - low	875
Total (w/o R&D) - high	1,175
Total - low	919
Total - high	1,645

Data				
Parameter	Value	Unit	Notes	Source
O&M jobs - low	650	jobs/Mtpa	Referred to as OAE in the linked source	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
O&M jobs - high	875	jobs/Mtpa	Referred to as OAE in the linked source	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - low	225	jobs/Mtpa	Referred to as OAE in the linked source	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - high	300	jobs/Mtpa	Referred to as OAE in the linked source	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf

Explanation and assumptions:
The job creation potential of electrochemical alkalinity production is taken from an existing report by the Rhodium Group, where it is referred to as part of OAE. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa for jobs for ocean alkalinity enhancement

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

Direct air capture

Job creation rate (jobs/Mtpa)	
R&D - low	40
R&D - high	440
Construction - low	550
Construction - high	725

Data				
Parameter	Value	Unit	Notes	Source
O&M jobs - low	250	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
O&M jobs - high	375	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - low	550	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf

Explanation and assumptions:
The job creation potential of direct air capture (DAC) is taken from an existing report by the Rhodium Group. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa for jobs for DAC

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

O&M - low	250
O&M - high	375
Total (w/o R&D) - low	800
Total (w/o R&D) - high	1,100
Total - low	840
Total - high	1,540

Construction jobs - high	725	jobs/Mtpa		the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf

Conventional CO2 storage

Job creation rate (jobs/Mtpa)	
R&D - low	88
R&D - high	1,032
Construction - low	-
Construction - high	-
O&M - low	-
O&M - high	-
Total (w/o R&D) - low	1,763
Total (w/o R&D) - high	2,580
Total - low	1,851
Total - high	3,612

Data				
Parameter	**Value**	**Unit**	**Notes**	**Source**
Total jobs - low	1,763	jobs/Mtpa	Internal modeleing, based on company interviews done for the linked source; excludes R&D	Scaling Technological Greenhouse Gas Removal: A Global Roadmap to 2050 - RMI
Total jobs - high	2,580	jobs/Mtpa	Internal modeleing, based on company interviews done for the linked source; excludes R&D	Scaling Technological Greenhouse Gas Removal: A Global Roadmap to 2050 - RMI

Explanation and assumptions:
The job creation potential of conventional CO2 storage was taken from RMI internal modeling and company interviews. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa from company interviews

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

In-situ mineralization

Job creation rate (jobs/Mtpa)	
R&D - low	88
R&D - high	1,032
Construction - low	-
Construction - high	-
O&M - low	-
O&M - high	-
Total (w/o R&D) - low	1,763
Total (w/o R&D) - high	2,580
Total - low	1,851
Total - high	3,612

Data				
Parameter	**Value**	**Unit**	**Notes**	**Source**
Total jobs - low	1,763	jobs/Mtpa	Internal modeleing, based on company interviews done for the linked source; excludes R&D	Scaling Technological Greenhouse Gas Removal: A Global Roadmap to 2050 - RMI
Total jobs - high	2,580	jobs/Mtpa	Internal modeleing, based on company interviews done for the linked source; excludes R&D	Scaling Technological Greenhouse Gas Removal: A Global Roadmap to 2050 - RMI

Explanation and assumptions:
The job creation potential of in-situ mineralization was taken from RMI internal modeling and company interviews. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa from company interviews

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

Ex-situ mineralization

Job creation rate (jobs/Mtpa)	
R&D - low	40
R&D - high	440
Construction - low	550
Construction - high	725
O&M - low	250

Data				
Parameter	**Value**	**Unit**	**Notes**	**Source**
O&M jobs - low	250	jobs/Mtpa	Assumes the same job creation profile as DAC	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
O&M jobs - high	375	jobs/Mtpa	Assumes the same job creation profile as DAC	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - low	550	jobs/Mtpa	Assumes the same job creation profile as DAC	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf
Construction jobs - high	725	jobs/Mtpa	Assumes the same job creation profile as DAC	the-benefits-of-innovation-an-assessment-of-the-economic-opportunities-of-highly-durable-carbon-dioxide-removal.pdf

Explanation and assumptions:
The job creation potential of ex-situ mineralization is taken from an existing report by the Rhodium Group, assuming a similar job creation profile to DAC. This assumption is based on viewing both DAC and ex-situ mineralization facilities as plants that take in CO2 and return a product. The number of R&D jobs was calculated by assuming a fixed percentage of jobs for a company are R&D jobs.

Data:
- jobs per Mtpa for jobs for DAC

Assumptions
- R&D jobs was calculated by assuming a fixed percentage of jobs (see R&D jobs section)

O&M - high	375
Total (w/o R&D) - low	800
Total (w/o R&D) - high	1,100
Total - low	840
Total - high	1,540